THE CHEMICAL COMPOSITION OF THE SOILS OF THE SOUTH-WESTERN DISTRICTS OF THE CAPE COLONY.

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(Plates XVII., XVIII., XIX., XX., XXI.)

Amongst the many valuable papers read before this Society from time to time no record is to be found of any dealing with the chemical composition of the various classes of soil met with in the Colony. This may, perhaps, be regarded as surprising to scientific investigators in other lands: have we not heard, again and again, almost *ad nauseam*, the agriculturist described as the country's backbone, and has not the soil been termed, and quite rightly, the only permanent and reliable source of wealth in any country? Such being the case, how is it that we have hitherto heard so little about it? One reason is clearly the paucity of men capable of conducting scientific research in this Colony. For private investigators, except they be men of considerable means, the researches involved in the analysis of a country's soils are far out of reach, and, all the world over, the practice has been for such investigations to be conducted under Government auspices. Where these inquiries have been set afoot, moreover, they have been carried out through the media of Agricultural Departments. Now in this country the Department of Agriculture is just getting into its teens: very unambitious was its inauguration, and whatever error, if any, there has been in its subsequent development, it has assuredly *not* been on the side of forced growth. Hence, when an analytical laboratory was instituted—the indispensable adjunct to a Department of Agriculture—it was on an extremely modest scale. Scientific research was, for the first few years of its existence, looked upon as an Utopian ideal, and even now one requires to tread the way cautiously and warily. The object, at the initiation of the laboratory, was rather to provide means for analysing such articles as solitary farmers and others might chance to submit for the purpose. It was the individual who was to be served rather than the country at large. For a few years this principle had been maintained, and in this state I found the Government analytical laboratory upon being placed in charge of it eight years ago. Things were expected to move slowly, and drastic changes were not to be dreamt of, so I had to remain perforce content with gradual developments.

It is just about ten years ago that circumstances were brought to my notice which ultimately led to a systematic investigation into the chemistry of the soils of the Colony. Towards the end of 1887, while performing certain investigations in connection with my University Fellowship, I was struck by the exceedingly small quantity of phosphoric oxide in some samples of oathay from the Bathurst district, that I was analysing. To this deficiency I ascribed the poor condition of the crops. For some time, too, there had been noticed a prevalence of a bone disease amongst the cattle of the district, and the Colonial Veterinary Surgeon expressed the opinion that this disease was due to a lack of phosphates in the food of the animals. My investigations now confirmed that view, and in remarking thereon in a report dated the 24th of February, 1890, I observed "Judging from the analysis of the plants only, I should say that the soil of the Colony generally appears to be rather poor in phosphates." So small was the amount of phosphatic material in the crops analysed that it seemed a marvel that they ever attained perfection—if the term perfection may be applied to such dwarfed and sickly specimens as they were. A year later I reverted to the subject, and remarked, "I do not regard the matter as settled satisfactorily, and commend it to the attention of the Grahamstown Agricultural School, hoping that ere long proper investigations will be made and the mystery cleared up."

The facts brought to light in connection with the investigations just alluded to showed me how beneficial fuller information respecting the soils of our various districts would be. Towards the end of 1892, therefore, I made a direct recommendation to Government that investigations with the object of eliciting some such information should be undertaken without delay. The assurance of warm support was readily given, and the operations commenced, the virgin clay soils of the Cape Division being the first to be dealt with.

Shortly after this work had been put in hand the services of the Government Botanist were requisitioned from Durbanville, in connection with a parasitic disease (Erysiphe graminis) that had appeared amongst the wheat in that neighbourhood. In connection with Professor MacOwan's investigations five samples of soil from the infected area were submitted for analysis. Fortunately the analytical survey of the soils had by that time advanced sufficiently to enable a comparison to be made between the virgin and cultivated soils of the locality, and in the following table one may see to what extent soil exhaustion had gone on.

	Average composition per cent. of Virgin Soils.	Cultivated Soils.
Lime..................	·291	·194
Potash	·133	·127
Phosphoric oxide...	·031	·015

In other words, the soil had been exhausted of ·097 per cent. of lime, ·006 per cent. of potash, and ·016 per cent. of phosphoric oxide. Roughly we may say that cultivation had removed from each acre of the surface soil 1,940 lbs. of lime, 120 lbs. of potash, and 320 lbs. of phosphoric oxide. To look at the matter from another point of view : for every pound by weight of lime removed from the soil by a crop of wheat, 4 lbs. of potash, and 3 lbs. of phosphoric oxide are needed; relatively to the other plant-food constituents of the soil, therefore, as well as absolutely, the amount of phosphoric oxide, meagre enough even in the virgin soils, had been halved in the process of cultivation; the crops were, in fact, starved in respect of this one essential nutritive element, and were in consequence quite unfitted to resist the attacks of parasitic diseases.

Before proceeding with the actual details of the work done it may be advisable to say a word or two on the general subject of soil analysis. It may possibly appear superfluous to dilate on the use and benefits of analyses of soils when addressing a Society such as this, and yet I am by no means sure that it is so, for there have not been wanting men of scientific repute who have not only cast doubts upon, but have even openly ridiculed the worth of such investigations. Thus a well-known author, who has given much information to the world on agricultural industries as carried on in the Australian and South African colonies,* "does not hesitate to affirm that the subject of analysis of soil has occupied quite an exaggerated position of importance, not only with the unlearned, but also among those who ought to have known better. One individual," this author proceeds to observe, "often of no repute in the scientific world, resolutely and dogmatically takes the lead, and many follow, sheep-like, without inquiry. This has been painfully the case in connection with soil analyses. . . . It is quite impossible to determine with certainty in the laboratory, or by any other test than the growth of crops upon it, whether an ordinary agricultural soil is good or inferior." Again †—"No analyst, using the ordinary processes

* Wallace: Rural Economy and Agriculture of Australia and New Zealand, pp. 167, 168.

† Wallace: *Op. cit.* p. 169.

for soil analysis, can determine whether or not such infinitesimal amounts as are required by the crops are present, or are not present, in an available form in a soil," and so on.

Sir Charles Cameron, on the other hand, remarks, * " The kind and amount of benefit to be derived from the analyses of soils are becoming every day more apparent. We cannot, indeed, from the results of an analysis prescribe in every case the kind of treatment by which a soil may at once be rendered most productive or even improved. In many cases, however, certain wants of the soil are directly pointed out by analyses; in others, modes of treatment are suggested by which a greater fertility is likely to be produced, and, as one's knowledge of the subject extends, we may hope to obtain, in every case, some useful directions for the improvement or more profitable culture of the land."

At one time it was suggested that all that was necessary in analysing a sample of soil was to reduce it to a fine powder, and then to take some of the powdered soil and ascertain how much, say, of potash, phosphoric oxide, or of lime, as the case may be, it contained. If much, the soil was pronounced fertile; if little, barren. Such was the opinion entertained by men of high eminence in their day: an advance, certainly, upon the opinion previously held, that plants were fed by water, and water alone, but an opinion nevertheless, capable of improvement, and improvement came. Baron von Liebig already saw that these views were not quite correct when he said—in 1858†—that soluble constituents of the soil sometimes entered into a kind of combination with other substances in the soil, and so lost their solubility, and at the same time their capacity for circulating about in the soil. It was found, moreover, on the other hand, that from the rootlets of plants exuded an acid possessing the property of acting on some of the insoluble constituents rendering them available to the plant, and in 1866 Dr. Cossa, Professor of Chemistry at an Italian university, pointed out ‡ that if the method of determining soluble constituents in soil were to give trustworthy results they would have to simulate as closely as possible nature's own mode of dissolving the plant-food constituents in the soil. It was plain that to take *all* that the soil contains in the way of potash, lime, phosphoric oxide, and nitrogen, as being so much plant food was erroneous, and to take *only that which was soluble in water* as being available would be no less faulty. Different chemists proposed different methods of settling the difficulty, but

* Johnston and Cameron: Elements of Agricultural Chemistry and Geology, p. 3.

† v. Liebig: Ueber das Verhalten der Ackerkrume zu den in Wasserlöslichen Nahrungsmitteln der Pflanzen.

‡ Fresenius: Zeitschrift für analytische Chemie, vol. 5, p. 161.

there was no *organised* mode of solving the problem until, early in the seventies, the Congress of German Experiment Stations took up the matter. Numerous experiments were carried on in laboratories all over the country, and side by side with each of these experiments the soil itself was directly appealed to by actual cultivation. The outcome of these investigations was that the agricultural chemists of Germany, assembled in congress, resolved to adopt certain fixed methods of analysing the soil in such a manner as to approach as closely as possible to natural processes; and this they did, first of all, not by pounding the soil, but by *sifting* it, and so excluding from the portion actually analysed big fragments of bone and other materials that would give a fictitious value to the soil, and would be of too large size to be successfully dealt with by the acids excreted from the plants' roots. A *fixed weight* of the sifted soil was then taken for analysis, treated with a *definite quantity* of *diluted* hydrochloric acid of a *certain strength* for a *stipulated time* at a *fixed temperature* and under *specified conditions.* Subsequently it was found that, in order to extract the variably available phosphoric oxide, different solvents would be necessary; and for this specific purpose water was used, and a solution of citric acid in ammonia liquor. By these means three "grades," if the expression may be applied, of phosphoric oxide are distinguished. The most immediately valuable part is that which dissolves when a *definite weight* of soil is *continuously* shaken with a *certain volume* of water for *half an hour;* next, that soluble under specified conditions in the ammonium citrate solution; and lastly, that insoluble in the latter solution. These methods, which found their chief exponent in the experiment station at Halle, gained such worldwide repute that, at the special request of the United States Department of Agriculture, they were published in book form in 1892. This, as already observed, was the first attempt to organise methods of soil analysis into a practically applicable code. Since then the official agricultural chemists of the United States have also adopted a provisional uniform method, thus following the lead of Germany. France, Italy, and even Russia have in turn followed up, and the United States, in the person of Dr. Wiley,* have rendered great service by collating all the methods in use, and thus international agreement on the subject has been brought appreciably nearer. In England there has been no organised attempt to deal with the matter, and many analysts are still content to follow ancient methods; no wonder, then, that one sometimes hears soil analysis cried down. In 1894, however, Dr. Bernard Dyer recom-

* Wiley: Principles and Practice of Agricultural Analysis, vol. i.

mended the use of citric acid for the extraction of both potash and phosphoric oxide, and, when the value of this method has been properly tested, it is possible that England also may fall into line with the other countries which have adopted standard methods of extracting available plant food from soils.

All will agree that, for agricultural purposes, an analysis of a soil should show only those quantities of the constituents which are really available. That is exactly the ideal that the German and American chemists have been aiming at, and that Dr. Dyer is following up. To say that they have wholly succeeded would be asserting far too much; yet those who are so fond of decrying soil analysis aim all their shafts at a method which (though they know it not) has long been superseded, in Germany and the United States of America, by others whose object is to extract from the soil only those materials which plants themselves can take out. Some chemists have sought to do this in some ways, some in others, but a method of which Dr. Dyer's is a modification has been used at Halle for determining available phosphates in soils years ago, and for this purpose such a method is now officially recognised practically the whole scientific world over. In brief, the *principle* of extracting available plant-food constituents is generally admitted amongst chemists of standing, the *mode* of applying this principle being the only point of difference. A few isolated persons, unaware of the progress made in the subject, are contending that the *principle itself is wrong*, and the unfortunate thing is that many do not understand how wide of the mark the arguments employed really are. Here, too, to employ the critic's boomerang, it may be said that "one individual, often of no repute in the scientific world, resolutely and dogmatically takes the lead, and many follow, sheep-like, without inquiry."

A few words may be needed regarding the methods employed in our analytical investigations of the Colony's soils, and first of all the collection of the sample requires attention. While travelling about the Colony collecting soils we have frequently been asked to include in our list soils from cultivated lands on this or that farm; soils, therefore, that have been modified by various or repeated cropping—soils, moreover, that have been in all probability considerably altered by the use of manures. For the occupier of that little plot of land an analysis of such a soil will probably have some value, but for the country at large, or even for the surrounding district, it is absolutely valueless. Such a sample is not typical of any extended area, because it has been altered by the agency of man, and, as Dr. Wiley observes, "The physical and chemical analyses of soils are entirely too costly to be applied to samples which represent nothing but themselves." * As our analyses are intended to a certain extent to ascertain the agricultural value of the soils over wide areas it becomes necessary to include as far as possible only virgin soils that have not been subjected to modifying influences. The practice has been to take the sample sufficiently below the surface to keep it clear of the top growth and accumulations, and then to extend downwards to a depth not exceeding 12 inches. After having been spread out in the laboratory for some days the soil is digested with water and washed through a ½-millimetre sieve by the aid of a small brush, that which passes through being dried and the residue from the wash water after evaporation added to it. The combined weight of the two is then calculated in percentage of the original soil taken, and entered as "fine earth." This fine earth is utilised for the determination of lime, potash, and phosphoric oxide in the soil. The residue which does not pass through the ½-millimetre meshes is, after drying, sifted through a sieve with meshes 1 millimetre in diameter; what passes through is known as "coarse sand," and this is included together with the fine earth in determining moisture, organic matter, chlorine, and nitrogen. Regarding these latter determinations I do not propose to say much on this occasion, rather confining my remarks to the inorganic plant-food constituents of the soil, namely lime, potash, and phosphoric oxide.

The first step in the actual analytical process is the *treatment of the soil with acid.* Two hundred grammes of the fine earth are placed in a large flask and treated with 400 c.c. of hydrochloric acid of specific gravity 1·115; allowed to remain for five days at the ordinary temperature, shaking thoroughly from time to time. After the prescribed period of digestion has expired, the extract is filtered through a dry pleated filter into a dry flask. Two hundred and fifty c.c. of the filtrate are evaporated to dryness in a shallow porcelain dish at first over a small open flame, then on the water bath, and finally on a sand bath or in an air oven at 120° Centigrade until perfectly dry. During evaporation a few cubic centimetres of strong nitric acid are added to the extract. The dry residue is moistened with strong nitric acid and again evaporated to dryness: to expel the nitric acid the residue is moistened with hydrochloric acid and evaporated on the water bath to as near dryness as possible, taking care to stir towards the end so as to prevent the formation of crusts. This final residue, after warming in the air bath for an hour, is treated with warm water and a 20 per cent. solution of hydrochloric acid, and is then washed over into a 250 c.c. flask, boiled for fifteen

* Wiley: *Op. cit.* p. 65.

minutes, and after cooling the liquid is filled up to the mark with distilled water and filtered into a suitable bottle. This filtered soil extract is then employed for the actual estimations of lime and potash.*

For the *determination of lime* 50 c.c. of the extract (equal to 25 grammes of soil) are removed by means of a pipette into a 250 c.c. boiling flask: after adding two or three drops of rosolic acid solution, ammonia is added very carefully by means of a dropping tube until a pinkish colour makes its appearance in the supernatant liquid. It is then boiled until the pink colour almost disappears again, the alumina and oxide of iron being thus precipitated. After cooling the flask is filled up to the mark, thoroughly shaken, and the contents filtered into a 300 c.c. bottle. One hundred c.c. of this clear filtrate (equal to 10 grammes of soil) are removed by a pipette into a 300 c.c. Erlenmeyer flask; three to five drops of acetic acid are added and 20 c.c. of a 4 per cent. ammonic oxalate solution. The mixture is placed on a water oven for six hours and then filtered through double filter papers. The precipitate on the filters is ignited at first over a Bunsen flame and is then strongly heated in a furnace for ten minutes. After cooling it is weighed and the lime calculated as CaO.

In determining potash another 50 c.c. of the filtered soil extract is placed in a 250 c.c. flask and boiled. Five c.c. of a 10 per cent. solution of baric chloride are added, and the mixture is boiled for some time for the precipitation of sulphuric acid. A few drops of rosolic acid are next added, and the mixture is boiled with ammonia as in the case of the lime determination. When partly cooled down 2 or 3 grammes of crystalline ammonic carbonate are added, and the temperature is once more raised to boiling-point in order to separate lime and barium. After complete precipitation of the latter the liquid is cooled, the flask filled up to the mark, and the contents filtered. Of this filtrate 100 c.c. (equivalent to 10 grammes of soil) are placed in a platinum basin and heated to dryness on a water bath. The dish containing the residue is heated on asbestos sheet and then carefully over a small open flame until all ammonium salts have been expelled. The residue is then washed through a filter with boiling water into a glass dish. Two c.c. of a 10 per cent. solution of platinic chloride are added, and the mixture is evaporated to dryness on the water bath. After cooling, some dilute alcohol (81 to 82 per cent.) is added to the residue, and it is allowed to stand for at least half an hour. It is now filtered through a Gooch crucible by aid of a filter pump, washed first with

* It should be observed that the soils from the Riversdale and Mossel Bay Divisions were extracted by means of a modified process. The results in these cases are hence not quite on all fours with the others, and due allowance should be made in comparing them.

96 per cent., and then with absolute alcohol, and dried for two hours in a water oven. The weight of the crucible containing the potassic platinic chloride having been taken, the precipitate is washed through with boiling water and the crucible, after again washing with alcohol, is dried and weighed, and the difference between the two weighings taken as the amount of potassic platinic chloride. This amount, multiplied by ·193 gives the quantity of potash (K_2O) in the 10 grammes of soil taken.

For the determination of phosphoric oxide 25 grammes of the "fine earth" is placed in a marked 500 c.c. flask, 25 cc. of concentrated nitric acid are added, and the mixture is thoroughly shaken. Fifty c.c. of concentrated sulphuric acid are next added and the mixture is again carefully shaken up. It is then gently heated, shaking at frequent intervals. If this does not lead to complete oxidation more nitric acid is added and the heating continued. Finally the mixture is cooled and diluted to the mark with distilled water: it is then well shaken and filtered. Two hundred c.c. of the filtered solution (equivalent to 10 grammes of soil) are placed in an Erlenmeyer flask of suitable size, and very nearly neutralised with strong ammonia solution, a few drops of nitric acid being used to acidulate the mixture in case the limit is overstepped. Two hundred c.c. of molybdic solution—prepared by dissolving 150 grammes of ammonic molybdate in a litre of water, and adding this to a litre of nitric acid of specific gravity 1·20—are added, and the mixture is heated to a temperature of 50° C. for three hours in a water oven, and allowed to cool completely. The liquid is decanted through a small filter and the precipitate in the flask washed with diluted molybdic solution. It is then dissolved with warm 5 per cent. ammonia, and the resulting solution is at once very faintly acidulated with hydrochloric acid. From a burette is then added 20 c.c. of magnesia mixture, drop by drop, at the rate of 1 c.c. every five seconds, and then 25 c.c. of 5 per cent. ammonia. The mixture is shaken for a short time and allowed to stand for two hours. The precipitate is filtered through a weighed Gooch crucible and washed with 5 per cent. ammonia solution. The crucible is dried at first on an iron plate and then ignited in a furnace for fifteen minutes. It is then cooled and weighed, and from the weight of the precipitate contained the amount of phosphoric oxide in the soil is calculated.

I have detailed the methods employed in our investigations at some length, for two reasons: firstly, where vastly different results are arrived at by the employment of different methods, it is always desirable to be able to gauge the significance of the results from a knowledge of the method; and secondly, when investigations, such as these, extend over a number of years, it is better far by the employment of one uniform method throughout the whole series, to ensure that the results shall be strictly comparable with one another, than to risk the almost certain unconformity likely to be produced by the adoption of new methods: hence it is advisable rather to adhere throughout to the method of analysis resolved on at the outset, and to state that method clearly, than from time to time to adopt the new and improved methods which the advances of scientific thought and investigation may develop.

The portion of the Colony selected for our operations happened to be identical with that traversed a year or two later by the Geological Survey, and from our standpoint it is not a little to be regretted that that work did not precede ours, as we would have been greatly assisted thereby. The portion I allude to comprises the south-western districts of the Colony extending from St. Helena Bay to Mossel Bay, and is made up of the divisions of Malmesbury, the Cape, Caledon, Bredasdorp, Swellendam, Robertson, Riversdale, and Mossel Bay. Since then we have extended our operations to the Divisions of George, Knysna, Uniondale, Oudtshoorn, Prince Albert, Ladismith, and Worcester, while in the Eastern Province the Divisions of Cathcart, Komgha, Butterworth, Willowvale, and St. Marks have been dealt with. I say again, it is a pity that at the outset of our investigations we did not have the advantage of the map published with the 1897 Report of the Geological Commission, covering as it does exactly the area of our operations during the years 1894–96. It is with that area I propose to deal in the present paper, and it must be remarked that even now the area surveyed has not been sufficiently extensive to allow of general conclusions being drawn, and therefore it is perhaps somewhat unwise to venture upon statements which time may yet disprove.

I have profited by Dr. Corstorphine's kindness in being able, as it were, to superimpose upon the maps* showing the localities whence our samples were collected, the map published with the Geological Commission's report, illustrating the geological formation in the south-western corner of the Colony. As every endeavour was used, when collecting the samples, to locate the site whence each one was taken as accurately as possible, we have thus been enabled to refer every sample to the underlying geological formation with a view to deducing conclusions from the results of the analyses.

The area with which I propose now to deal includes part of the divisions of Malmesbury and the Cape, the Caledon, Bredasdorp,

* Reduced divisional maps were shown when the paper was read.

Riversdale, and Mossel Bay Divisions, and the southern part of the Divisions of Swellendam and Robertson. Within this area 212 samples of soil were collected. Amongst these the geological formations chiefly represented are the Malmesbury and Bokkeveld beds, 75 samples having been collected from the former and 76 from the latter. Besides these we have analysed 10 from the Witteberg beds and 6 lying on Table Mountain sandstone. In eighteen cases the underlying rock was granite and in one the soil rested upon a substratum of Dwyka conglomerate, while 26 soils were taken from areas covered by conglomerates and recent deposits. By far the larger number of soils analysed, therefore, came from the geological formations now termed the Malmesbury and Bokkeveld beds. True granite soils were very few in number, but, taken in conjunction with a number of granite soils analysed by Dr. Hahn, and published in the Vine Diseases Commission's report in 1881, some conclusions may possibly be drawn. It may therefore be of value to tabulate the percentages of lime, potash, and phosphoric oxide yielded by these analyses ; they are as follows :—

Description of Soil.	Lime.	Potash.	Phosphoric Oxide.
1. Partly decomposed granite from Hout Bay	...	·014	·002
2. Partly decomposed granite from Groot Constantia	·025	·011	·009
3. Decomposed granite from Bellevue, Groot Constantia	...	·052	·053
4. ,, ,, ,,	·008	·020	·019
5. Decomposed granite from High Constantia	·002	·013	·019
6. ,, ,, ,,	·081	·043	·075
7. Decomposed granite (uncultivated, Red Constantia soil)	·037	·056	·014
8. Alluvial granite soil from Bergvliet	·281	·151	·172
9. From Hout Bay	·016	·002	·002
10. ,, ,,	·026	·012	·011
11. Groot Constantia	·009	·015	·001
12. ,, ,,	·069	·049	·011
13. ,, ,,	·039	·031	·019
14. Vlaggeberg, Eerste River	·018	·010	·011
15. ,, ,, ,,	·181	·017	·011
16. ,, ,, ,,	·063	·004	·007
17. Stellenbosch	·014	·019	·002
18. Somerset West	·034	·029	trace
19. ,, ,,	·080	·025	trace
20. Papkuilsfontein, Malmesbury	trace	·049	trace
21. ,, ,, ,,	·046	·028	·012

On looking through this table the one feature that is pre-eminently striking beyond all others is the difference in composition between the alluvial soil No. 8, and all the rest, which are primary granite soils. In the essentials of plant food it is far richer than any other soil. Excluding, then, that sample, we get the following as the average content of the remaining twenty primary granitic soils (I have added the maximum and minimum in respect of each constituent):—

Lime.			Potash.			Phosphoric Oxide.		
Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.
...	·037	1·81	·002	·025	·056	trace	·014	·075

That is to say, the average primary granite soil is poor in all three of the above-mentioned constituents, but of course it will be remembered that many of these soils have been under lengthened cultivation. The poverty of the soil is due to the fact that the minerals of which the granite is composed have not been completely disintegrated, and thus the plant food they contain, though present, is not present in a form available to the plant. For instance, in the case of soil No. 1, the felspar, from which the lime is derived, had remained undecomposed, and hence the sample contained no available lime. A comparison between samples 3 and 4 is interesting: though the former was richer in potash and phosphoric oxide, it was quite destitute of available lime; no wonder, therefore, that the vines on this patch were found to be sickly, whereas the quantity of lime in sample No. 4, small though it was, sufficed to maintain the vines in health. Compare also Nos. 5 and 6: on the latter soil the vines were in good condition, on the former they were diseased. A supply of lime was subsequently given to soil No. 5, and the disease disappeared at once. Between Nos. 11 and 12 a similar comparison holds good, with this in addition—that No. 11 is exceptionally poor in both phosphates and lime. Leaving out of account the alluvial soil No. 8, there is not one amongst the series that could be described as having a normal percentage of lime for agricultural purposes: there is a fair amount in No. 15, but all the others are decidedly poor in that constituent. Nos. 3 and 7 have a fair amount of potash, but here too all the others, excepting of course No. 8, are poor. Nos. 3 and 6 contain phosphoric oxide in fair amount, the rest are poor, some extremely so.

I may mention that I have regarded as poor any soil containing less than ·1 per cent. of lime, or ·05 per cent. of potash or phosphoric oxide, the normal amounts being ·25 to ·5 per cent. for lime, ·15 to ·25 per cent. for potash, and ·1 per cent. for phosphoric oxide.

I have referred to these analyses of Dr. Hahn's because the granite soils being, as it were, nearer home and their investigation occupying the earlier position in point of time, they form a convenient basis with which to compare later work.

For obvious reasons it will not be advisable to take the soils collected and analysed by us in their chronological order. Eighteen samples were collected from the granite formation which extends between St. Helena Bay and Koeberg. It was, however, thought that, as the granitic soils of the Cape Peninsula had already been to some extent explored, it would be advisable to go farther afield and enter upon a formation regarding whose soils very little, if anything, had up till then been learnt—from a chemical standpoint, of course. Hence, even while collecting soils from this granitic area, our aim was to confine ourselves as much as possible to the alluvial soils derived from the clay state lying to the east of the granite. It may, however, be well to give a complete list of the soils collected from the granite formation. Together with the results of the analytical examination they will be found comprised in the following table:—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—MALMESBURY							
Field-Cornetcy : Groenekloof East							
22. Alexanderfontein	·485	3·117	·0010	·129	·081	·035	·045
23. Rheboksfontein	·797	4·155	·0032	·117	·095	·098	·048
24. Platteklip	·561	2·235	·0012	·035	·046	·102	·050
Field-Cornetcy : Zwartwater							
25. Drooge Vlei	7·254	9·262	·0058	·140	1·99	·492	·063
26. ,, ...	·932	2·136	·0057	·028	·156	·122	·028
27. Zwart Water	·776	1·810	·0025	·035	·125	·075	·033
28. ,, ...	·476	2·036	·0017	·028	·108	·054	·039
Field-Cornetcy : Schryvers							
29. Geelbeksfontein	1·852	16·259	·226	·325	1·159	·443	·180
30. Oostenwal	·778	3·293	·0013	·042	·364	·124	·052
Field-Cornetcy : St. Helena Bay							
31. Patrijzen Berg	·468	1·121	·0009	·049	·062	·046	·027
32. Schuitjes Klip	1·008	2·533	·0093	·035	·015	·021	·050
33. Uitkomst	2·324	3·477	·0017	·091	·418	·105	·094
34. Noodhulp	1·855	2·553	·0011	·077	·165	·062	·046
35. Holle Vallei	1·278	4·823	·0024	·084	·043	·039	·027
36. Klip Rug	1·940	4·303	·0016	·112	·139	·060	·045

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—BREDASDORP *Field-Cornetcy: Bloemfontein*							
37. Avoca...........................	·38	2·36	·015	·17	·32	·071	·013
DIVISION—MOSSEL BAY *Field-Cornetcy: Before Attaquas Kloof*							
38. Hartebeeste Kraal	3·52	5·68	·032	·056	·15	·63	·074
39. ,, ,, ...	·92	2·47	·0071	·031	·13	·18	·061

Scarcely any in the foregoing table can be classed as true granitic soils, either primary or alluvial. Nos. 22, 23, and 24 are alluvial clays, the last of the three being apparently, judging from its appearance, affected by the granite below; this also shows itself in the smaller amount of lime and higher percentage of potash. Nos. 25, 26, 27, and 28 are all clay soils, the last three being of a rather sandy nature: it is somewhat interesting to note that No 25, a stiff, grey-coloured soil, is locally described as "rust resistent," whereas this is not the case with sample No. 28, a sandy soil. When one reflects on the circumstances that the former of these two soils is well supplied with the essential fertilising ingredients of soils, and that No. 28 is the poorest of the four soils, one reason for the local opinion on the subject becomes evident. The crops grown under the advantages of the fertile soil are better able to remain proof against attack than those grown on soil such as that represented by No. 28, which just misses being a poor all-round soil. In the case of sample No. 25 the effect on the composition of the soil of the compacted blown sand underlying the immediate surface soil throughout extensive portions of the Malmesbury Division is clearly noticeable. No. 29 is a humus soil of considerable fertility—so productive, in fact, that fallowing is rendered unnecessary. The underlying limestone here, too, greatly aids the fertility of the soil. No. 30 is the first granitic soil on this list, but it is not a pure granite, being intermixed with the lime deposit; and here, as in some other cases, manuring is never practised. It is well known amongst many farmers in this neighbourhood that the limestone soils to a large extent withstand rust, and that at times, when the grain grown on sandy soil is almost completely ravaged, the crops standing on the lime soils are only slightly affected. Nos. 31 and 32 are rather sandy, but 33 is an alluvial clay soil; 34, 35, and 36 are sandy loams.

The foregoing samples are of too miscellaneous a nature to enable one to draw definite general conclusions, but it is noteworthy that the soils more or less affected by the underlying limestone, such as Nos. 25, 26, 29, 30, 33, are also proportionately richer not only in lime—as is but natural—but also in potash, than the other samples. The ultimate origin of the large amount of potash in soils of this nature is a point of some interest worth elucidating; it does not seem improbable that it is caused by the *débris* of granitic rocks being mixed with the compacted sand: from the blown sand the potash could certainly not be derived; least of all is such an idea plausible when we consider that the quantity of potash available in some of these soils ranges as high as 5 per cent. No. 29 is the only soil that can be called rich in phosphates; Nos. 24, 25, 30, 32, and 33 have a fair amount, but all the rest are decidedly poor in this respect.

The sample No. 37, taken from above a small outcrop of granite in the Bredasdorp Division, is an alluvial sandy soil derived from the surrounding hills, which are composed of Table Mountain sandstone; the amount of lime in this soil is satisfactory, and it has a fair quantity of potash, but is poor in phosphates.

From the mass of granite which, commencing north-west of Mossel Bay, extends over a considerable portion of the George Division, two samples were taken on the farm Hartebeest Kraal; they are numbered 38 and 39, the former a red and the latter a black soil. Both these samples contained a fair amount of lime, but No. 38 was very rich in potash, and indeed No. 39 was not unsatisfactory in this respect; the phosphoric oxide is moderate in amount in both cases. The preponderance of potash appears to be due to the felspar of the granite, but the question is still being investigated, inasmuch as a number of samples, taken further eastward, are at the present time under analysis.

Turning now to the Malmesbury clay slate beds, 75 samples were collected and analysed; these were distributed as follows:—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—CAPE *Field-Cornetcy: Tygerberg and Kuils River*							
40. Maastricht	1·33	15·50	·054	·128	·48	·045	·028
41. ,, ...	2·97	10·52	·057	·201	·64	·27	·028
42. Eversdal	1·37	6·94	·0053	·134	·39	·12	·044
43. ,, ...	1·75	7·64	·0028	·134	·35	·026	·062

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Durban							
44. Diemersdal	1·03	4·60	·021	·106	·23	·14	·028
45. ,, ...	1·22	6·67	·0074	·134	·25	·27	·019
46. Phesante Kraal	1·38	5·31	·0021	·089	·23	·043	·044
47. ,, ,, ...	·63	2·84	·0024	·123	·12	·025	·032
48. ,, ,, ...	1·12	5·79	·0060	·084	·32	·023	·017
Field-Cornetcy: Palen and Rietvlei							
49. Visser's Hok	1·61	4·16	·0024	...	·24	·43	·035
50. Government Land north of Visser's Hok.........	·27	·51	·0005	·056	·046	·039	·0038
Field-Cornetcy: Koeberg No. 1							
51. Vrymansfontein	·70	2·85	·0095	·056	·22	·35	·020
52. ,, ...	·44	2·11	·0053	·061	·11	·12	·020
53. Rondeboschjesberg	·94	4·00	·0021	·044	·15	·16	·026
54. Ongegund	1·19	3·92	·0064	...	·23	·24	·026
55. Altona	1·40	4·35	·0006	...	·13	·071	·062
56. Adderley	1·60	2·05	·0026	·061	·061	·070	·019
Field-Cornetcy: Koeberg No. 2							
57. Klein Olifant's Kop ...	·81	1·73	·0004	·061	·095	·038	·023
58. Kalkfontein	·62	1·64	·0018	...	·061	·036	·017
59. Uitkyk	·96	2·36	·021	...	·067	·065	·013
60 ,, ...	1·65	4·20	·0016	...	·16	·093	·076
61. ,, ...	2·04	2·67	·0028	...	·16	·098	·040
62. Dassen Vallei	·96	2·59	·0013	...	·070	·094	·026
63. Klein Dassen Berg	·236	·808	·0015	·035	·061	·021	·029
Field-Cornetcy: Blaauwberg							
64. Lange Rug	·836	2·167	·037	·028	·057	·030	·017
DIVISION—MALMESBURY *Field-Cornetcy: Mosselbanks River*							
65. Kalabas Kraal Station	·295	·846	·0006	·014	·059	·041	·016
Field-Cornetcy: Middle Zwartland							
66. Twee Kuilen...............	·49	1·90	·0003	·061	·056	·107	·051
67. ,, ...	·68	2·47	·0003	·078	·092	·171	·071
68. Vaderlandsche Riet Kuil	1·16	5·24	·0008	·095	·136	·128	·064
69. Bloemendals Fontein...	·142	1·069	·0004	·050	·059	·038	·025
70. Rheboksfontein	·906	2·911	·0014	·091	·049	·031	·030
71. Michiel Heyns Kraal ...	·668	2·296	·0011	·070	·108	·039	·038
72. ,, ,, ,, ...	7·160	15·358	·0056	·252	·369	·033	·080
Field-Cornetcy: Groene Kloof East							
73. Klipfontein	·172	·954	·0008	·067	·039	·042	·033
74. Karnemelksfontein	1·033	4·439	·0014	·089	·147	·059	·041
75. ,, ...	·294	2·157	·0006	·072	·062	·064	·022

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Honing Berg							
76. Holle Rivier	·936	2·495	·0009	·063	·064	·074	·032
Field-Cornetcy: Zwartland							
77. Witkei	·98	3·60	·0022	·117	·160	·130	·056
78. ,, ...	·80	1·86	·0347	·072	·056	·077	·044
79. ,, ...	1·05	2·79	·0010	·095	·108	·101	·051
80. Olifants Kuil	·62	2·68	·0004	·056	·104	·062	·038
81. Geel Kuil	1·23	4·02	·0007	·033	·036	·119	·035
82. New Rush..................	·60	2·99	·0012	·078	·028	·144	·071
83. ,, ...	·58	2·61	·0010	·084	·082	·090	·064
84. ,, ...	·59	2·53	·0031	·061	·098	·092	·051
85. Schildpad Vallei	·46	2·04	·0002	·067	·060	·020	·074
86. Hooi Kraal	·68	2·94	·0009	·084	·032	·033	·053
87. Zwartfontein	·35	1·72	·0005	·072	·064	·042	·040
88. Vogelstruisfontein	·73	5·17	·0002	·100	·076	·090	·076
89. Klein Zoutfontein	·37	1·63	·0003	·056	·052	·042	·066
90. ,, ,, ...	1·68	3·17	·0005	·156	·068	·090	·063
91. Zoutfontein	·31	1·76	·0002	·077	·036	·045	·086
Field-Cornetcy: Zout Rivier							
92. Haazenkraal...............	·243	1·060	·0050	·042	·024	·045	·124
93. Portugueeschfontein ...	·169	·586	·0005	·021	·053	·018	·134
94. Bosjesmans Kloof	·870	1·831	·0103	·091	·187	·066	·042
95. ,, ,, ...	1·084	7·898	·0042	·133	·010	·052	·058
96. Breek Muur	·703	1·548	·0020	·077	·046	·048	·042
97. Leliefontein	1·942	4·091	·0108	·126	·256	·075	·027
98. ,, ...	·394	1·204	·0009	·035	·039	·026	·038
Field-Cornetcy: Saldanha Bay							
99. Springfontein	·520	2·439	·0016	·035	4·715	·058	·025
100. Spanjaardsbosch	·415	·939	·0015	·049	·231	·037	·075
101. Cloeteskraal	1·165	2·594	·0006	·049	·220	·068	·055
102. Lang Riet Vlei	1·980	2·972	·0147	·070	1·826	·182	·053
103. ,, ,, ...	·577	1·312	·0022	·047	·073	·063	·027
104. ,, ,, ...	·203	·540	·0006	·028	·063	·046	·025
105. ,, ,, ...	·509	1·012	·0008	·028	·114	·061	·034
Field-Cornetcy; St. Helena Bay							
106. Muishondfontein	·413	·675	·0006	·084	.084	·042	·048
107. Eenzaamheid............	·348	·666	·0010	·056	·034	·035	·027
DIVISION—BREDASDORP *Field-Cornetcy: Bloemfontein*							
108. Vogelstruis Kraal	·67	3·27	·0099	·15	·11	·063	·0092
109. Ronde Rivier	1·80	8·08	·045	·16	·26	·045	·016
110. Koude Rivier	·74	3·45	·012	·13	·12	·036	·0082
111. ,, ,, ...	·71	4·06	·0092	·12	·14	·016	·022

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Zoetendals Vallei							
112. Miere Kraal	·95	5·14	·014	·15	·28	·13	·026
113. Elands Drift	1·18	3·58	·0085	·15	·11	·10	·013
DIVISION—ROBERTSON *Field-Cornetcy: Robertson*							
114. Keur Kloof	1·11	4·51	·014	·11	·72	·14	·011

On comparing the map showing the various localities whence the foregoing samples were collected with the diagram (Plate XVII.), which illustrates the chemical composition of each sample a few broad features strike one. The first is this, that the amount of available lime averages ·5 per cent. in the soils about Durban, thins out to about ·1 per cent., and even less in the northern part of the Koeberg district, and remains fairly uniform as we go north to near Hopefield, the average percentage of lime in the 35 soils collected on the clay slate formation in the Field-Cornetcies, Koeberg No. 2, Blaauwberg, Mosselbank River, Middle Zwartland, Groene Kloof East, Honing Berg, and Zwartland being only ·078 per cent.; in other words, the average soil in the area just mentioned is decidedly poor in lime.

The following will show this more clearly: The four soils collected within the Field-Cornetcy of Tygerberg and Kuils River, Nos. 40 to 43, yielded an average percentage of ·47 of available lime. The next strip of country, lying to the north of this, and mainly within the Durban Field-Cornetcy, represented by the seven samples 44 to 49 and 54 gave an average of ·23 per cent. Next come Nos. 50 to 53, north of Durban, and constituting the southern portion of the Koeberg district; these give an average of ·13 per cent. of lime. The middle part of the same district, comprising Nos. 55 to 62—8 samples in all—yields an average of ·10 per cent. In the northern portion of Koeberg and the southern part of Zwartland we have the samples 63, 64, and 65, giving an average percentage of ·059. As we go further north we pass over samples 71 and 72, which are humus soils and probably also affected by the granite boss to eastward as well as the extent of granite lying to the west. Nos. 69, 70, and 73 represent the next area, and the average in this case is ·049 per cent. After this it becomes difficult to trace the gradation owing to the influence of the underlying limestone. A diagram (see Plate XVIII.) enables us to grasp the continuous diminution of lime at a glance.

About Hopefield and to the north-west of it there is again an increase of lime in the soil, clearly traceable to the compacted sand dunes previously referred to. In some cases—samples 99 and 102 for instance—the amount of lime is very large proportionately to the other constituents of the soil, for here, on the clay slate, the simultaneous increase of potash is not so noticeable as, for instance, in soils 25 and 29 where the underlying rock is granite.

Diverse from the changes in the lime content of the soil, strangely enough, is a marked increase in the phosphoric oxide as one travels northwards from Durban. Taking the clay slate soils of the Cape and Malmesbury Divisions as a whole one may conveniently divide them into three sections as regards the amount of phosphates the soil contains. First of all may be taken the area south of the farm "Uitkyk" in the Koeberg district, then the stretch of country between "Uitkyk" and the Great Berg River, expressly excluding the Zwartland soils, and finally the area covered by the Zwartland Field-Cornetcy. The first of these three areas comprises samples 40 to 58—19 in all; they average ·029 per cent. of phosphoric oxide. The samples taken from the next area are 34 in number, comprised in two sets, namely Nos. 59 to 76 and 92 to 107. In these the average percentage of phosphoric oxide is respectively ·041 and ·046: the former represents the country north, and the latter that south of Zwartland. The Zwartland area comprises the 15 samples 77 to 91, and they yield an average of ·058.

There is a diminution of potash, somewhat similar to that already noticed in the case of the lime, as we proceed from south to north within the area under consideration, but in this case it is not as striking nor as regular. Several of the southernmost soils contain a respectable proportion of potash—for instance, Nos. 41, 45, 49, 51, and 54, the percentage of potash in which averages ·32: these soils may all be said to be rich in potash. In the Zwartland area there is a noticeable difference in respect of potash between the western soils and eastern soils; the former, comprising Nos. 77 to 84, contain on an average ·102 per cent., the minimum being ·077, whereas the samples taken from the more easterly part of the Field-Cornetcy, Nos. 85 to 91 yield an average of only ·060 including a minimum of ·020.

Summarising our results with respect to the clay soils of the Cape and Malmesbury districts we may say that no less than 16 out of the 68 soils examined were poor in all three of the essential inorganic elements of plant food; there is one such poverty-stricken patch about the middle of the Koeberg district, represented by samples 50, 57, and 58, and two others of apparently wider extent in the northern portion of the same district and in the south of Zwartland; the former of these two is represented by samples 63, 64, and 65, and the latter by Nos. 69, 70, and 73. As many as 45 of the soils are poor in phosphoric oxide; five of these are poor in phosphoric oxide and potash (and this is notably the case with the farm Phesante Kraal, near Durban), while eight are poor in phosphoric oxide and lime, and, as already observed, 16 are poor all round, leaving a balance of 16 samples which show poverty in phosphoric oxide only. Eight samples were poor in lime only, three poor in potash only, and five poor in both lime and potash. There are, therefore, only seven samples that do not show a deficiency in respect of one or other of the three fertilising constituents, and even out of these seven, six are no better than fair all round, while the seventh—No. 102—is rich in lime, contains a normal amount of potash and a fair quantity of phosphoric oxide.

The six Bredasdorp soils examined were all, without exception, poor in phosphoric oxide; two of them—Nos. 108 and 110—particularly; all of these soils, however, yielded at least a fair amount of lime, but in three—Nos. 109, 110, and 111—the potash was likewise deficient. The average composition of these six soils is—lime ·17, potash ·065, phosphoric oxide ·016. The sample from the Robertson Division showed a good percentage of lime and a fair amount of potash, but phosphoric oxide was deficient.

We now come to the soils of the Bokkeveld beds, numbering 76. The following table shows the analytical results:—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—CALEDON.							
Field-Cornetcy: Upper River Zonder End							
115. Middelplants	·73	2·67	·55	·084	·270	·13	·033
Field-Cornetcy: Zwart River							
116. Zwart River	1·24	6·69	·0086	·15	·034	·13	·059
117. ,, ,,	·51	2·15	·093	·091	·018	·043	·038
Field-Cornetcy: Bot and Palmiet Rivers							
118. Riet Fontein	1·60	6·57	·0038	·17	·093	·050	·058
119. The Vlei	1·44	6·33	·0040	·15	·028	·056	·036
120. Lang Hoogte	2·04	11·71	·0038	·25	·083	·073	·032
121. ,, ,,	1·42	6·60	·0056	·15	·030	·038	·058
122. Avontuur	1·48	7·57	·017	·15	·026	·098	·049

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Caledon							
123. Muurton	·87	4·36	·0042	·11	·039	·036	·056
124. ,,	1·37	5·25	·018	·10	·018	·055	·038
125. Klein Steenboks River ...	1·27	4·94	·0042	·15	·150	·076	·056
126. Weltevreden	1·56	6·14	·0050	·15	·024	·073	·056
127. Dunghye Park	1·67	7·42	·0055	·20	·045	·087	·059
Field-Cornetcy: Uilenkraal							
128. Good Hope	1·28	5·21	·0070	·15	·040	·044	·051
129. Weltevreden	·84	3·22	·0027	·11	·038	·024	·056
Field-Cornetcy: Goudini							
130. Goudini	1·58	7·88	·0058	·20	·016	·072	·036
Field-Cornetcy: Lower River Zonder End							
131. Roode Vlei	1·93	7·98	·0034	·17	·058	·068	·13
132. Jongens Klip	1·93	7·04	·0064	·18	·032	·071	·051
133. Alexanders Kloof	1·87	7·19	·0034	·20	·045	·078	·061
134. Ganze Kraal	2·10	8·20	·014	·22	·058	·049	·061
135. ,,	1·37	4·39	·0049	·098	·030	·061	·041
136. Tygerhoek	·95	4·60	·0042	·13	·026	·042	·038
137. The Oaks	1·19	6·04	·0037	·16	·041	·045	·056
DIVISION—BREDASDORP *Field-Cornetcy: Napier*							
138. Klippe Drift	1·25	7·95	·0096	·18	·20	·062	·011
139. Leeuwen River	1·63	9·65	·019	·18	·15	·18	·026
140. Halfaampjes Kraal	1·39	6·94	·011	·15	·18	·19	·032
141. Quarrie	1·27	7·01	·029	·17	·16	·11	·026
142. Kilppe Drift	0·95	5·86	·021	·16	·37	·13	·028
143. ,,	0·91	4·23	·028	·17	·094	·089	·019
Field-Cornetcy: The Ruggens							
144. Rem Hoogte	1·32	6·91	·017	·15	·15	·19	·038
145. Koeranna	1·43	7·19	·043	·077	·15	·15	·030
146. Haasjes Drift	1·65	6·34	·0071	·15	·16	·12	·024
147. Nooitgedacht	0·71	3·96	·0064	·19	·094	·15	·022
148. Patrys Kraal	1·02	2·89	·017	·16	·20	·098	·010
DIVISION—SWELLENDAM *Field-Cornetcy: River Zonder End*							
149. Appels Kraal	0·09	0·77	·0056	·11	·084	·034	·0048
150. ,,	1·05	5·41	·025	·18	·060	·035	·011
151. ,,	0·57	3·36	·013	·16	·044	·049	·015
152. ,,	0·75	3·85	·0085	·14	·058	·10	·014
153. Stormsvlei	0·68	3·59	·093	·15	·14	·078	·016
154. Verdwaal Kloof	0·95	6·90	·018	·16	·25	·084	·013
155. Klipfontein	1·44	7·20	·028	·14	·16	·13	·012
Field-Cornetcy: Kluitjes Kraal							
156. Vryheid	·051	3·73	·011	·16	·080	·055	·017
157. Kluitjes Kraal	·080	4·78	·086	·15	·084	·14	·022

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy : Swellendam							
158. Appelsboch	1·50	4·64	·0028	·028	·096	·015	·036
159. Oude Post	1·58	5·91	·0025	·065	·15	·053	·041
160. Kinko	1·08	4·14	·019	·098	·33	·062	·023
Field-Cornetcy : Breede River							
161. Uitvlugt	1·76	5·65	·010	·098	1·18	·43	·009
162. Rhenosterfontein	·59	1·87	·0073	·056	·16	·099	·010
Field-Cornetcy : Heidelberg							
163. Klein Duine Rug	·84	2·98	·011	·042	·32	·018	·014
164. Wagen Drift	·91	4·25	·019	·056	·37	·087	·019
165. Asch Kraal	2·68	7·53	·086	·035	2·73	·29	·041
Field-Cornetcy : Karnemelk River							
166. Honig Klip	1·70	9·26	·015	·12	·40	·045	·0080
167. Karnemelk River	4·82	4·07	·048	·077	·37	·11	·031
Field-Cornetcy : Zuurbraak							
168. Melkhout Boom	2·86	9·07	·016	·084	·23	·060	·019
169. ,, ,,	2·07	4·67	·015	·084	·083	·099	·036
DIVISION—ROBERTSON *Field-Cornetcy : Middle Bosjesveld*							
170. Vrolykheid	·34	1·94	·023	·077	1·08	·070	·060
171. Riet Vallei	1·35	5·01	·014	·14	·13	·10	·021
172. Bosjesmans River	2·09	6·30	·0088	·16	·79	·32	·051
173. ,, ,,	1·48	4·96	·035	·056	·29	·22	·068
DIVISION—RIVERSDALE *Field-Cornetcy : Onder Duivenhoek's River*							
174. Oude Muragie	2·10	5·20	·014	·028	·013	·36	·090
175. Jan Pienaars Rivier	1·79	4·85	·017	·056	·11	·21	·58
Field-Cornetcy : Vette Rivier							
176. Brak Rivier	1·73	4·20	·010	·15	·12	·13	·058
177. ,, ,,	1·14	4·81	·012	·056	·12	·32	·081
178. Oude Bosch	1·66	3·78	·010	·056	·19	·14	·087
Field-Cornetcy : Riversdale							
179. Novo	2·05	4·01	·012	·15	·18	·24	·099
180. Klein Rivier	3·63	5·71	·013	·028	·13	·24	·15
Field-Cornetcy : Valsch Rivier							
181. Boschjesfontein	2·69	4·50	·062	·070	·14	·19	·069
182. Middelste Drift	4·05	4·87	·012	·11	·13	·34	·056
Field-Cornetcy : Buffels Kraal							
183. Zandfontein	2·58	2·85	·0062	·028	·11	·15	·044
184. Drooge Rug	0·96	2·13	·0053	·028	·14	·26	·069

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Kaffir Kuils River							
185. Hooge Kraal	2·38	4·68	·011	·029	·10	·29	·089
186. Tartouwa	1·61	4·32	·025	·027	·13	·24	·044
DIVISION—MOSSEL BAY *Field-Cornetcy: South Middelveld*							
187. Buffels Drift	2·52	6·29	·0062	·056	·43	·39	·13
188. Hartjesfontein	2·99	4·87	·037	·043	·23	·46	·070
189. ,, ...	6·95	10·24	·035	·17	·59	·87	·12
Field-Cornetcy: Mossel Bay							
190. Patrysfontein	·78	2·29	·026	·13	·10	·13	·033

Here again, as in the case of the clay slate soils, we may fairly compare the map with the diagram (Plate XIX.) showing the chemical composition of the individual samples, and again some salient features are noticeable at the first glance. The Caledon soils, for instance, are far the lowest in respect of the quantity of lime contained, the average percentage of lime in the 23 soils being only ·054, with a minimum of ·016 and a maximum of ·27; in fact, only two samples, Nos. 115 and 125, attain to more than ·1 per cent. This is a very much worse exhibition than anything afforded by the Malmesbury slates. Passing eastward into the Bredasdorp Division, a considerable improvement manifests itself. The lime rises to an average percentage of ·174 in the 11 soils of this division, an average percentage about five times as great as that in the Caledon soils. This percentage is maintained in the western part of the Swellendam Division represented by the Field-Cornetcies of River Zonder End, Kluitjes Kraal, and Swellendam, the average of 12 soils collected in this area being ·128. The diminution is due to the low lime contents of the four soils, Nos. 149, 150, 151, and 152, from the farm Appelskraal. Now these samples, it must be remarked, lie just on the verge of the mass of sandstone which forms the River Zonder End range, and are apparently influenced thereby. To this influence must also be ascribed the poverty in lime exhibited by the Caledon soils, lying, as they do, in a tract of country almost entirely hemmed in by sandstone. When we reach the Bredasdorp Division and the western part of the Swellendam District we emerge from this sphere of influence, and the lime becomes less deficient. I have included sample No. 160 from the farm Kinko in the western half of the

Swellendam Division ; but manifestly that is not its proper place, for it lies east of the Breede River and of the Witteberg beds which surround the village of Swellendam, and hence belongs to an area which, as we shall see, differs somewhat from the western part of the division. Compare in the diagram showing the composition of the various soils, this sample No. 160, with the others belonging to the western part of the district, namely, Nos. 153 to 159, and the difference becomes immediately apparent. The lime shows a definite preponderance over that of the other samples. It is the beginning of an increase which becomes much more noticeable as we go still further eastwards. This is clearly seen on the diagram in the case of all the samples from 161 up to 167 both inclusive. Nos. 168 and 169, which of course belong to this part of the division, are again poorer, but they are also within reach of the sandstone formation just to the north.

The potash, it will be noticed from the diagram, increases with the lime, though the ratio of increase is smaller. Strange to say, however, the amount of phosphoric oxide is apparently in inverse proportion to the amount of lime. The reason of this curious fact I have not been able to solve. These remarks apply only to the soils of the Caledon, Bredasdorp, and Swellendam Divisions. On coming to Riversdale we find, conjointly with an increase of phosphoric oxide, a fairly large increase of potash, while the lime is about the same as in the western portion of the Swellendam District. Still further east, in the division of Mossel Bay, three out of the four soils analysed showed an all-round improvement on the soils of the more westerly districts.

It is almost to be expected that soils derived essentially from a sandstone formation can scarcely claim to be otherwise than poor. Only six such soils were analysed, all lying on sandstone, in the Caledon Division. Their analytical results are as follows :—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—CALEDON							
Field-Cornetcy : Bot and Palmiet Rivers							
191. Dasjesfontein	1·27	6·43	·0034	·13	·098	·060	·12
Field-Cornetcy : Caledon							
192. Klipheuvel	2·05	8·30	·0031	·19	·080	·078	·077
193. Dunghye Park	1·49	5·81	·0021	·14	·038	·048	·072

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Uilen Kraal							
194. Paarde Berg........................	·88	3·37	·0049	·091	·054	·041	·046
195. ,, ...	1·57	5·21	·0055	·13	·029	·24	·032
Field-Cornetcy: Goudini							
196. Klein Wolvegat	1·38	6·57	·0097	·17	·025	·045	·036

Lime is lacking right through the series; but for one exception this would be true of potash as well; of the latter there is a satisfactory amount in No. 195. The last 3 soils are poor in phosphoric oxide; there is a fair amount in Nos. 192 and 193, and No. 191 is really good in this particular. No. 194, I would remark in passing, is found by Mr. de Villiers, the occupant of the farm, to be very poor, the ears of corn generally shrivelling up without coming to perfection, whereas No. 195, though really even poorer in lime and phosphoric oxide, was stated by him to be very rich, due no doubt to the amount of potash it contains.

The samples collected from above the Witteberg beds were 10 in number, and the results of their analyses are given in the following table:—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—CALEDON							
Field-Cornetcy: Zwart River							
197. Bok Kraal	1·06	3·85	·0061	·13	·034	·076	·038
DIVISION—ROBERTSON							
Field-Cornetcy: Voor Cogmans Kloof							
198. Riet Vallei	1·54	2·45	·0071	·077	2·65	·15	·017
199. ,, ...	1·26	3·64	·014	·11	·89	·070	·0037
Field-Cornetcy: Robertson							
200. Hex River	2·09	7·60	·095	·098	1·20	·12	·083
DIVISION—SWELLENDAM							
Field-Cornetcy: Swellendam							
201. Klippe River	·86	6·26	·018	·16	·29	·12	·040
202 Distelsfontein..................	·65	4·30	·0019	·042	·16	·074	·052
203. Bonteboks Kloof...............	1·81	6·76	·019	·098	·63	·23	·044

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Breede River							
204. Zwartklip........................	1·35	5·38	·0068	·077	·45	·23	·018
Field-Cornetcy: Klip River							
205. Boschjesmans Pad............	1·43	5·60	·015	·084	·46	·10	·010
DIVISION—RIVERSDALE							
Field-Cornetcy: Vette River							
206. Kweek Kraal	2·66	6·59	·040	·11	·16	·22	·13

Compared with the other soils examined, these Witteberg soils show remarkably high percentages of lime. Only one is deficient, namely No. 197, a Caledon soil, which in this respect conforms to the generality of soils in that division. No. 202, in appearance, general character, and composition, approaches nearest to the soils of the Caledon Division, but even here the percentage of lime is fair; this is also the case with sample No. 206; Nos. 201, 204, and 205 contain a satisfactory quantity of lime, 199 and 203 are really good in this respect, while 198 and 200 are decidedly rich. The soils of this series all yield a fair proportion of potash, but there are only two—namely, Nos. 200 and 202—that can be described as anything else than absolutely poor in phosphates, while No. 202 borders on poverty and No. 200 is slightly better off, though not satisfactory.

Coming to the soils overlying the more recent formations, 21 samples were taken from the Enon deposits, chiefly in the Riversdale and Mossel Bay Divisions; these yielded the following analytical results:—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—SWELLENDAM							
Field-Cornetcy: Heidelberg							
207. Duivenhoks River	·21	2·16	·0057	·063	·64	·033	·011
Field-Cornetcy: Karnemelk River							
208. Hooi Kraal	1·64	4·97	·053	·15	·51	·11	·015
DIVISION—RIVERSDALE							
Field-Cornetcy: Vette Rivier							
209. Vette Rivier........................	·91	1·66	·0088	·056	·093	·22	·13

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
Field-Cornetcy: Krombeks Rivier							
210. Spiegel Rivier	4·27	4·71	·020	·056	·075	·27	·065
211. " "	4·35	5·95	·019	·084	·025	·26	·099
Field-Cornetcy: Riversdale							
212. Novo	3·32	4·98	·012	·028	·15	·11	·078
213. Kruis Rivier	1·13	2·99	·013	·028	·13	·24	·11
214. Doorn Kraal	2·08	3·85	·054	·028	·18	·28	·061
Field-Cornetcy: Valsch Rivier							
215. Assegaai Bosch	1·88	3·57	·013	·030	·23	·082	·061
Field-Cornetcy: Buffels Kraal							
216. Zandfontein	4·27	5·45	·014	·14	·93	·29	·22
DIVISION—MOSSEL BAY							
Field-Cornetcy: Upper Gouritz River							
217. Hemelrood	1·58	3·54	·011	·028	·10	·39	·074
218. Heuning Bosch	2·52	4·98	·016	·042	.16	·20	·054
Field-Cornetcy: Before Attaquas Kloof							
219. Hagel Kraal	2·66	5·67	·011	·030	·15	·25	·11
220. " "	2·75	4·47	·040	·17	·13	·36	·059
221. Ruiter Bosch	1·97	4·17	·012	·044	·15	·080	·064
Field-Cornetcy: Brak River							
222. Great Brak River	2·73	5·01	·0079	·046	·39	·58	·056
223. " " "	1·97	6·29	·047	·044	·30	·34	·10
224. Klipheuvel	2·12	4·41	·044	·057	·31	·56	·092
225. "	1·05	2·13	·044	·029	·15	·26	·058
226. Geelbeks Vallei	2·21	5·71	·057	·056	·40	·76	·15
227. Hartenbosch	·46	·89	·021	·045	·11	·14	·046

Here for the first time we meet with some really good all-round soils. Many of the others have been found to be rich in one or two of the three essential inorganic plant-food constituents, but in all cases this has been counterbalanced by a lack of one, frequently of two constituents, and phosphoric oxide has generally been the one lacking. Now we come across a few samples which are in every respect satisfactory, and especially prominent are Nos. 216 and 226. The former of these two soils is typical of the Gouritz River basin; the richness of the latter is tempered by its being brack. In respect of the fertilising elements the samples from 212 to 226 inclusive constitute the most satisfactory group of the entire range of soils examined. Though it would be too much to say that addition of suitable fertilisers will not improve their quality, yet it is certain that none of them are in any respect what may be called poor soils.

From the surface deposits and sands along the Bredasdorp and Riversdale coast 5 samples were collected; these yielded the following results:—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—BREDASDORP *Field-Cornetcy: Bredasdorp*							
228. Nachtwacht	·54	2·83	·011	·15	·25	·076	·028
229. ,,	1·10	5·65	·018	·16	·40	·12	·015
230. Matjesfontein	·92	5·30	·011	·16	·31	·23	·0038
DIVISION—RIVERSDALE *Field-Cornetcy: Onder, Duwenhoeks River.*							
231. Honig Fontein	1·49	2·23	·004	·059	·44	·074	·098
232. Watergat	·82	2·47	·003	·030	·19	·25	·082

As their formation would lead one to expect, the amount of lime is not unsatisfactory in these soils; nor indeed is the potash, but the phosphates stand in need of augmentation, especially in the three Bredasdorp soils, which are decidedly poor.

One more sample completes our list; it was taken from the Dwyka formation north-west of Robertson, and its analytical results are as follows:—

Name of Farm and No. of Sample.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
DIVISION—ROBERTSON *Field-Cornetcy: Robertson*							
233. Hex River	·38	1·53	·0053	·13	·34	·066	·036

The amount of lime in this sample is normal; there is not much, but still a fair quantity of potash, but the almost generally prevalent poverty in phosphates is again noticeable. Of course, to draw any general conclusions from the analysis of a single sample is out of the question.

Rather interesting results were yielded by analyses of 6 soils from the Malmesbury District, which may be taken as supplementary to the main series of investigations. While travelling in the district mentioned my attention had been more than once drawn by the local farmers to numerous slight elevations, from 1 to 4 feet in height, and 20 or more yards in diameter; the soil of these hillocks was alleged to be extremely rich, and cereals of all kinds were said to grow on them with luxuriance, while on the lower ground, between the elevations, the soil would be poor and produce scanty crops. It was represented to me that if these lower portions could be worked up by artificial fertilisers so as to equal in fertility the soil of the hillocks, a great improvement in the average yield of the crops would be discernible. I was further told that it was not the practice ever to manure these hillocks, and that there were some lands on which wheat had been sown for nearly a century without the hillocks either getting any manure or becoming exhausted. Mr. J. P. Cloete, Alexanderfontein, states that for the last four years he has been urging farmers to use lime largely on the poor, cold soils, between the hillocks; but, he added, "I am sorry to say that though I have preached, they have not heeded—though I have quoted instances to them of a very poor land having yielded a heavy crop of wheat by the aid of a good dressing of lime."*

In order to ascertain more definitely by chemical analysis what difference, if any, existed between the high- and low-lying soils, samples were procured from some of the hillocks said to be so rich, and also from the adjoining grounds. Those from the hillocks are marked A, B, and C; those from the lower grounds A′, B′, and C′. In every case the soil was taken from ground that had been cultivated.

No.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
A	1·574	5·834	·0106	·175	·146	·121	·061
B	1·146	3·182	·0078	·189	·072	·075	·072
C	1·472	5·012	·0042	·126	·096	·095	·073
A′	1·010	4.332	·0261	·119	·014	·114	·049
B′	1·092	2.640	·0159	·112	·014	·045	·028
C′	1·278	4.296	·0078	·119	·014	·095	·055

The mechanical analysis of the soil, I may say, did not reveal anything very striking, there being little difference in fineness of grain between the soil taken from the hillocks and that below.

* The point had first been raised in connection with the two samples from Karnemelksfontein, Nos. 74 and 75, the former being from high- and the latter from low-lying ground. The retentive power for moisture appeared greater in the case of No. 74, which was also the richer in plant food materials.

Taking into consideration the composition of the fine earth, in which determinations of lime, potash, and phosphoric oxide were made, it may be said at once that in every case the soils taken from the low-lying ground were exceedingly poor in lime, and herein lies the great difference between the hillock soils and those below ; even samples B and C are very deficient in this respect, although considerably superior to samples A′, B′, and C′. A contains lime in fair amount. The potash present in A, B, and C, is fair in quantity, but B′ is rather poor. A′ and C′ likewise show a moderate percentage of potash, though in each case poorer than the corresponding samples from the hillocks. As far as the phosphates are concerned, there is a fair percentage in the hillock soils, and also, though to a less extent, in sample C′, but A′ and B′ are decidedly poor. Clearly the chemical analysis tends to confirm the popular idea ; and yet the difference all round is not as wide as some of the statements made might possibly have led one to expect. To this observation there is just the exception already noted—that of the lime.

Physically, as well as chemically, the hillock soils are slightly superior. In water retentive power their average stands higher than that of the soils around. To this fact I have already alluded. The organic matter in the hillock soils is also better than in the others, and the former are likewise the richer in nitrogen. The inferiority of the low-lying soils also comes out in the amounts of common salt they contain, as indicated by the percentage of chlorine ; thus every single one of the seven sets of determinations made shows the soils from the hillocks to be better adapted for agriculture, they contain more of the six useful constituents and less of the one that is harmful.

Some soils were also collected in the Wellington District, where a somewhat similar configuration prevails, and on the farm "Groenberg" a sample of soil E′ from level ground was taken, as well as one E from a hillock. Analysis seemed here also to confirm the popular theory, as may be seen from the following table :—

No.	Water.	Organic Matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric Oxide.
E	·76	5·57	·0255	·006	·064	·171	·074
E′	·76	5·11	·006	·003	·037	·084	·077

Of course the characteristics of the Wellington District are not strictly comparable with those of Malmesbury, but it is noteworthy that there is a marked difference in both the lime and potash of these two soils; both are poor in lime, it is true, yet the lime in E is nearly double that in E′. The quantity of potash in E is also quite normal, though it is but moderate in amount in E′.

Under all the circumstances, to revert again to the Malmesbury soils, it seems quite feasible that the process of levelling down the hillocks—said to have been attended with success in one instance—may in some cases lead to an all-round increase in fertility, notably where the hillocks are numerous.

It appears reasonable to suppose, from what these results reveal that an addition of lime would lead to an improvement. In the Malmesbury District there are numerous outcrops of lime—for instance, on the farms Drooge Vlei, Geelbeksfontein, Springfontein, and Lang Riet Vlei. Even if levelling down does not achieve the desired result, there should be plenty of lime near at hand on which to draw for a supply.

It may be useful to compare the average percentage composition of the hillock soils with those from below. The results, calculated on the unsifted soils, are as follows:—

	Lime.	Potash.	Phosphoric Oxide.
Hillock ground	·078	·073	·051
Level ground	·010	·061	·032

Calculated in pounds per acre to a depth of 6 inches of soil, this would amount to:—

	Lime.	Potash.	Phosphoric Oxide.
Hillock ground	1,560	1,460	1,020
Level ground	200	1,220	640

Hence, generally speaking, to bring the latter soils up to the fertility of the former, they would require per acre over half a ton of lime, together with about 200 lbs. of potash and 400 lbs. of phosphoric oxide; in other words, the equivalent of a ton each of Kainit and Thomas' phosphate per acre. At the same time it would not do to rest content with these additions, for so we would only be levelling up the general fertility to that of the hillocks, which are themselves in want of improvement. In fact, the lime in the latter may safely be trebled and the potash and phosphoric oxide doubled.

Reviewing the entire area covered by these analytical investigations, it is difficult, if not impossible, to trace well-defined family resemblances between the members of a series of soils overlying the same geological formation; similarity between samples is geographical rather than geological. For instance, the Caledon soils all present certain distinguishing features, easily discernible on the diagrams, no matter, apparently, whether the underlying rock be Table Mountain sandstone or belong to the Bokkeveld or Witteberg beds; and again, though the Enon soils of the Riversdale and Mossel Bay Divisions are all round the richest, yet they do not differ very widely from the soils of the same districts overlying the Bokkeveld beds.

Without for the moment considering the geological relations of the soil, some interesting information may be afforded by making two cross-country cuts, one almost due east and west from the farm Rietfontein in the western part of the Caledon Division, terminating near the mouth of the Great Brak River; and the other beginning from the same farm, running in an east-south-easterly direction, and reaching the coast about midway between Struys Point and Cape Infanta; as we travel along these lines let us take the soils lying nearest to hand, on either side, for consideration. Taking, then, the south-easterly course first, we meet in succession the soils enumerated in the following list (compare Plate XX.):—

No.	Lime.	Potash.	Phosphoric Oxide.
118. Rietfontein	·093	·050	·058
119. The Vlei	·028	·056	·036
120. Lang Hoogte	·083	·073	·032
121. ,, ,,	·030	·038	·058
122. Avontuur	·026	·098	·049
124. Muurton	·018	·055	·038
123. ,,	·039	·036	·056
125. Klein Steenboks River	·150	·076	·056
126. Weltevreden	·024	·073	·056
127. Dunghye Park	·045	·087	·059
130. Goudini	·016	·072	·036
132. Jongens Klip	·032	·071	·051
131. Roode Vlei	·058	·068	·13
139. Leeuwen River	·15	·18	·026
140. Half Aampjes Kraal	·18	·19	·032
142. Klippe Drift	·37	·13	·028
143. ,, ,,	·094	·089	·019
141. Quarrie	·16	·11	·026
147. Nooitegedacht	·094	·15	·022
145. Koeranna	·15	·15	·030
144. Rem Hoogte	·15	·19	·038
146. Haasjes Drift	·16	·12	·024
148. Patrys Kraal	·20	·098	·010
230. Matjesfontein	·31	·23	·038
228. Nachtwacht	·25	·076	·028
229. ,,	·40	·12	·015

A somewhat zigzag course having been taken in passing from point to point, it is scarcely possible for this, as well as for other obvious reasons, to expect anything in the way of regular gradation in the composition of the soils collected along the line; but it is clear that there is a noticeable increase both in lime and potash as we move onwards, and a corresponding decrease in respect of phosphoric oxide. The first few soils of the series are poor in lime and not very satisfactory as to potash and phosphates; the last few are very poor in phosphates, but, with few exceptions, show normal amounts of lime and potash.

Now taking an easterly course from the same starting-point, the following samples come into consideration (compare Plate XXI.):—

No.	Lime.	Potash.	Phosphoric Oxide.
118. Rietfontein	·093	·050	·058
117. Zwart River	·018	·043	·038
116. ,, ,,	·034	·13	·059
137. The Oaks	·041	·045	·056
134. Ganze Kraal	·058	·049	·061
135. ,, ,,	·030	·061	·041
136. Tygerhoek	·026	·042	·038
151. Appels Kraal	·044	·049	·015
150. ,, ,,	·060	·035	·011
149. ,, ,,	·084	·034	·0048
152. ,, ,,	·058	·10	·014
156. Vryheid	·080	·055	·017
157. Kluitjes Kraal	·084	·14	·022
201. Klippe River	·29	·12	·040
202. Distelsfontein	·16	·074	·052
160. Kinko	·33	·062	·023
166. Honig Klip	·40	·045	·0080
167. Karnemelk River	·37	·11	·031
208. Hooi Kraal	·51	·11	·015
207. Duivenhoks River	·64	·033	·011
206. Kweek Kraal	·16	·22	·13
176. Brak River	·12	·13	·058
177. ,, ,,	·12	·32	·081
214. Doorn Kraal	·18	·28	·061
213. Kruis Rivier	·13	·24	·11
215. Assegaai Bosch	·23	·082	·061
181. Boschjesfontein	·14	·19	·069
182. Middelste Drift	·13	·34	·056
183. Zandfontein	·11	·15	·044
217. Hemelrood	·10	·39	·074
218. Heuningbosch	·16	·20	·054
219. Hagel Kraal	·15	·25	·11
220. ,, ,,	·13	·36	·059
38. Hartebeeste Kraal	·15	·63	·074
39. ,, ,,	·13	·18	·061
222. Great Brak River	·39	·58	·056
223. ,, ,, ,,	·30	·34	·10

Here we first of all notice a change of composition somewhat similar to that drawn attention to in connection with the last-mentioned series, an increase with regard to lime and potash, a decrease in phosphoric oxide. This change proceeds more or less regularly up to the village of Heidelberg, but after that the lime undergoes a sudden diminution from ·5 to between ·1 and ·2 per cent., and remains comparatively uniform along the rest of the line; the potash continues to increase more and more, and the phosphates also show a sudden augmentation and remain, like the lime, more or less uniform thereafter. In popular language we may say that the soils, starting the series with a fair amount of phosphoric oxide, though poor in lime and not much better in potash, on reaching the eastern part of the Swellendam Division, become poorer than ever in the first-named constituent, although they show a good amount of lime and a fair quantity of potash. Across the river the lime diminishes and the phosphoric oxide increases, but both still remain fair throughout, while the potash attains to a normal condition and afterwards becomes in parts really rich, notably in the neighbourhood of the granite formation north of Mossel Bay.

Only 45 soils out of the entire series of 212 examined show normal proportions of lime; the remaining 167 cannot be said to be more than fairly well supplied, and of these 86 are decidedly poor. With regard to phosphoric oxide the case is even worse; here no less than 124 out of the 212 soils must be classed as poor, and of the whole range of samples only 15—that is to say, less than 8 per cent.—reach the normal standard. As to potash, conditions are rather more satisfactory; 57 samples show normal amounts, and only 53 are actually poor. These results show that, as far as my investigations have gone, my surmise of ten years ago was fairly correct; the great want of most of our soils is phosphatic material, and, next to that, lime. And all the while, for years in succession, we have continued exporting bones by hundreds of tons, and bones consist mainly of phosphate of lime and thus supply the very essential most lacking in our soils. Until a few years ago judicious fertilising was all but absolutely unknown in this Colony; the principle on which manuring was carried on may be instanced by the following: In one of the districts traversed I found that the practice was to manipulate with farmyard manure the lands adjacent to the homestead, guano being reserved for those at greater distances or in less accessible situations—hillsides, for instance. Here there was no inquiry after the needs of the soil and the fitness of the fertiliser to supply those needs; it was all a question of which is the easier to employ. There is an immense amount of education to be done in this respect, and from its very nature and the country's circumstances it is an education that takes time. More rational inquiry is now being made after the proper fertilisers to apply to particular soils than was the case in years gone by. None the less there still is a very extraordinary rush on guano as the hoped-for saviour of the land from all its ills, and people will not recognise that on poor lands this method of treatment results in all the more speedy depletion of the soil, for guano, by virtue mainly of its nitrogen, is a stimulant, and the usual results of stimulants follow its use. What is known to agricultural chemists as the law of the minimum should be borne in mind. Briefly stated, it is this: The growth and development of plant material is regulated by the amount of that particular form of plant food which is present in smallest proportion. If one particular substance required by the plant is deficient in the soil, no excess, however great, of other varieties of plant food will cover the deficiency. The soil may contain abundance of nitrogen, lime, and potash, for instance, but if phosphates are absent, or present only in small amount, no crop can reach perfection; for one reason, because the quantities of the former taken up are proportionate to the quantity of the latter available; hence, if only *one* of the plant-food constituents is deficient, the crop suffers as much as if *all* were wanting.

Now to supply stimulating manures in such cases is worse than useless, as the reaction is sure to follow. Under the influence of the stimulant the plant makes, as it were, a special effort to get sufficient phosphates as an adjustment to the other nutritive constituents, and the result is a more rapid impoverishment than would otherwise have been the case, inevitably bringing on a collapse from which no amount of stimulants will be able to rouse the land again.

Moreover, the lack of one constituent is sometimes not only the indirect, but the immediate cause of others being deficient. Research has shown that nitrifying bacteria need phosphates for their development: hence lack of phosphates goes hand in hand with retarded nitrification. This latter process, besides, cannot go on except in a soil sufficiently alkaline, and it is therefore also retarded by a defective lime supply, for the lime neutralises acidity in the soil and renders it ready for the reception of the nitric acid formed in the process of nitrification. Thus we see that the supply of nitrogen is also dependent upon the presence of a sufficiency of lime and phosphates in the soil.

From a utilitarian point of view one cannot help regarding it as in the highest degree unfortunate that we should spend millions upon millions in fouling our rivers and other sources of water supply and in casting into the sea what nature meant to be restored to the earth whence it came. Every sewer we construct is in a sense an additional step towards the impoverishment of the land, and all the refuse we cast away instead of employing, tends further in that direction. The recent discoveries regarding the functions of bacteria with respect to the assimilation of nitrogen in the soil help to convince us that the soil is the laboratory where garbage is refined and rendered fit for use, and in our war with nature we are only fighting our own interests by depriving the soil slowly but surely of what is indispensable to it.

With regard to rust and similar diseases in cereal crops it must be remembered that a well-nourished and cared-for child is, other things being equal, better able to resist the attacks of disease than one living in a vitiated atmosphere, badly fed, and poorly clad. The statistics regarding tuberculosis, for instance, tell an unmistakable tale in this respect. As with human, so with plant life: when a soil becomes exhausted, and the crops are no longer able to draw from it adequate supplies of plant food, they fall an easy prey to the diseases which they resisted successfully while the soil was in better condition. We hear of grain districts where the ravages of rust become more calamitous and more widespread every year. The first, or one of the first, of the warnings given by the hungry land of its approaching exhaustion should not be despised, and the important matter for consideration is not to give the soil some fertiliser, no matter what, at haphazard, but to adjust the manure to the needs of the soil.